Business model analysis for the interaction between smart grid and mobile network operators

Linda Salahaldin*

École Supérieure du Commerce Extérieur,
ESCE International Business School,
10 rue Sextius Michel, 75015 Paris, France
Email: linda.salahaldin@esce.fr
*Corresponding author

Eftychia Alexandri

Orange Labs Networks,
44 Avenue de la République,
92320 Châtillon, France
Email: eftychia.alexandri@orange.com

Nabyla Daidj

IMT-BS, Université Paris-Saclay,
91025, Evry, France
Email: nabyla.daidj@imt-bs.eu

Abstract: This paper explores the interaction between mobile network operators (MNOs) and smart grid operators from an economic and strategic point of view. We first present the emerging new actors in the evolving smart grid value chain. We then focus on the role of MNOs and study the different roles they could play in this value chain, not only as connectivity providers for connecting consumers to distributed energy storage and production facilities and for ensuring demand-response, but also with regards to their expertise as Internet of Things (IoT) players and their energy generation and storage assets. Based on this ecosystem analysis, we build three business models canvasses for the MNO as a Demand Response (DR) aggregator, as a Virtual Power Plant (VPP) and as an enhanced VPP where it also acts as a prosumer with generation/storage facilities. We show that the first two services fit very well with the European context, while the third is well suited for sub-Saharan African countries.

Keywords: ecosystem; mobile network operator; smart grid; business model canvas; business and green energy.

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Biographical notes: Linda Salahaldin is an associate professor at ESCE International Business School. She received her MS in mathematics applied to economics and finance and a PhD in economics and finance from Paris

Dauphine University. Her research topics include real options, investing under uncertainty, decision making and funding of innovation.

Eftychia Alexandri works on business model analysis and generation within Orange. Prior to that she worked on the evolution of cellular access networks, and on resource allocation algorithms inspired from artificial intelligence and machine learning techniques. She holds a degree in Electrical and Computer Engineering from the National Technical University of Athens (NTUA), Greece, 1996; a Masters' degree in Mobile Networks from Institut National des Télécommunications (INT), France, 1998; a PhD on Information Technology from Versailles University, France, 2003; a Master's on Cinema from Sorbonne Nouvelle, 2011, and a BBA from Neoma Business School, 2015.

Nabyla Daidj is an associate professor at IMT-BS, Université Paris-Saclay. She holds a PhD in economics from University of Paris I Panthéon-Sorbonne. Her teaching and research interests are corporate strategy, inter-organisational relationships (strategic alliances, networks, business ecosystems) and firms' performance in a context of co-opetition. Currently, she is studying the sources of value creation in ICT firms. She has published more than 44 publications (including 10 journal papers, 2 books, 11 book chapters, 5 strategic case studies and 18 international conferences).

1 Introduction

As global energy demand keeps increasing (Xerfi, 2015), the answer cannot be just to build new infrastructure and open-up markets; the electricity grid needs to be optimised to meet the demands of sustainable development. The 'smart grid' concept has been proposed as a solution to the problem of matching electricity supply and demand (Blumsack and Fernandez, 2012). A smart grid must be sustainable from an economic, social as well as environmental viewpoint. The Smart Grids European Technology Platform defines smart grids as 'electricity networks that can intelligently integrate the behaviour and actions of all users connected to it: generators, consumers and those that do both, in order to efficiently deliver sustainable, economic and secure electricity supplies' (Xenias et al., 2015). Smart grids are expected to experience a tremendous growth in the upcoming years with the objective of progressively abandoning fossil and nuclear energy production in favour of distributed renewable energy production (Rodriguez-Calvo et al., 2018). In parallel, fossil fuels and the emission of greenhouse gasses critically impact the global environment. By focusing on better techniques and processes, businesses can help towards an economic, sustainable and environmentally friendly future (Tantau and Staiger, 2018). From a business ecosystem point of view, the electricity industry has been until recently fairly stable, but it could now be on the brink of a disruptive change with the emergence of smart grids. At industry level, electricity firms have traditionally controlled and managed most of the value chain, from generation, transmission and distribution to front-end services. The emergence of smart grids is altering their value chains and business models, leading to higher complexity in electricity businesses and bringing new players to the game. Burger and Luke (2016) have conducted an empirical analysis of the most common business models for the deployment of distributed energy resources. Focus is provided on demand-response and energy management systems, electricity and thermal storage, and solar photovoltaic business models. The authors highlight that regulatory and policy environment is a significant, if not the most significant, driver of business model structure.

Even if new entrants are expected to fundamentally change the game, little effort has been put forth to clarify and to understand the position and the different opportunities of the new industry entrants; for example telecommunication companies, energy storage manufacturers, software developers, etc. (Tricoire, 2015; Xenias et al., 2015). Among these new entrants, Mobile Network Operators (MNOs) have vast opportunities due to their already existing assets. In particular, MNOs operate wide area networks that are able to reliably connect energy production facilities and consumers for a better load balancing of the smart grid (demand-response service). They have also deployed, in several countries, distributed solar and wind energy generation and storage equipment in their radio sites. Finally, they also have Internet of Things (IoT) platforms and good customer relationships, allowing them to propose added-value services directly to consumers. With regard to these advantages, cooperation between MNOs and smart grid operators seems promising, at least from a technological point of view. For instance, Hassan et al. (2015) show the feasibility of powering a mobile network with solar energy panels and demonstrate a considerable reduction in the resulting electricity bill. Labidi et al (2018) show that MNOs can use jointly their local energy generation equipment and the batteries of their radio sites to regulate their on-grid energy consumption depending on the energy price, to participate in the demand-response service, and also to sell energy to the grid when suitable.

However, despite these technological and business assets, Tricoire (2015) shows that actors from the telecommunications sector have so far only been able to provide fuzzy and unclear visions of what future smart grids will look like, and that as a result they are largely absent from the dominant smart grid discourse. Due to this absence of a clear strategy of MNOs with regards to the process of smart grid transition, ‘electricity utilities are building new business models based on taking partial or total ownership of the wireless network’ (5G PPP, 2015). Private Virtual Network Operator and Private Dedicated Network are examples of these partial or total ownership models (METIS, 2016). While in the former case the telecommunications radio network and the frequency license remain under the control of the telecom operator, the latter case corresponds to a situation where the electricity operator builds a fully dedicated wireless network to support smart grid and smart meter needs, and is indeed in possession of both telecom equipment and frequency license, as for Dutch DSO electricity operator (5G PPP, 2015).

The aim of this study is to bring more insights about the role of MNOs in smart grids transitions and to build corresponding business models. This involvement of MNOs in the smart grid ecosystem not only allows them to benefit from their technological assets for generating new revenue streams, but also contributes to sustainable energy programs in developing regions, where innovations in terms of partnerships and business models are essential for facilitating energy access (Chaurey et al., 2012). In addition, such private initiatives contribute to the unbundling of the vertically integrated utilities in developing countries and introduce private investment and management, as advocated in recent literature (Jamasb et al., 2018).

We start in Section 2 by exposing the main emerging activities in smart grids and illustrating, using examples from European and African countries, how actors in the telecommunications sector are starting to participate in these emerging activities. We then position the MNOs in the smart grid ecosystem, first as a prosumer and a small-scale storage facilitator, and then as a key player in the demand response service and in the connectivity services for the smart grid. Based on this positioning, we develop in Section 3 business model canvasses for the interaction of MNOs with smart grids for these different roles. Section 4 analyses both European and African contexts and identifies the business model canvasses that are most suitable to each context. Section 5 concludes the paper.

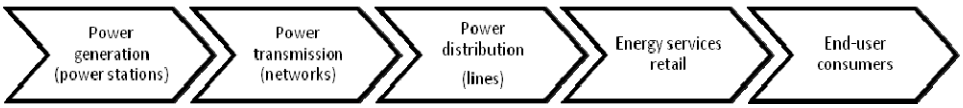
2 Mobile network operators in the smart grid ecosystem

2.1 The emergence of new activities with smart grid transition

The flow of electricity in most European countries is characterised by four main activities: generation, transmission, distribution and finally consumption. Generators are power plants which produce electricity at a large scale from different energy resources. The power plants are connected to high-voltage transmission networks and this high-voltage electricity is transported over long distances before arriving at regional distribution networks. These transmission activities are assumed by Transmission System Owners (TSO). The distribution activities are maintained by Distribution Network Operators (DNOs) and electricity retailers who both play a role in supplying electricity to end consumers. Electricity consumers are the end users of electricity. There is a wide variety of electricity consumer types, from domestic users through to public transport and industrial users using electricity to power their manufacturing processes.

This classical value chain represented below is experiencing radical changes with the advent of smart grids. In several European countries, for example from the 1950s to the 1990s, most national incumbent companies, vertically integrated, played a key role as major electricity generators as well as network operators and distributors (Figure 1).

Figure 1 The traditional energy value chain



This situation has evolved in the 2000s with the liberalisation of the electricity market in Europe and, more generally, the deregulation of network industries around the world. In addition, the innovations in infrastructure and the growing adoption and integration of new smart grid technologies have disrupted the energy sector. Achieving environmental benefits and creating new business opportunities are the two most often cited advantages of using smart grids and related technologies. The emergence of new players is driven by four main activities of the smart grids as follows:

1 *Renewable energy generation activities*: In the context of smart grids, energy generation is becoming more and more distributed. One can differentiate between large-scale renewable energy generation[1] (e.g. based on large wind farms) and small-scale production made by energy prosumers and aggregated in Virtual Power Plants (VPP). VPPs are essentially an aggregation of electricity flows coming from small-scale distributed energy generators or energy storage facilities.

2. *Renewable energy storage activities*: The large variability in renewable energy production increases the demand for energy storage infrastructure. This infrastructure must be distributed to cope with the distributed nature of production and spans from large to small scale, thereby leading to the emerging trend of using all available batteries (e.g. in smart homes and in electric vehicles). Electric car manufacturers thus enter the ecosystem from this perspective.
3. *Demand-response services*: It has been shown that peak demand occurs only about five per cent of the time (i.e. a few hundred hours a year) (Niesten and Alkemade, 2016). This means that several power plants or equivalent have to be built and maintained although their productive capacity is only occasionally used. Demand response can help flatten the demand curve and reduce demand peaks. Non-traditional, indirect ways of energy storage (e.g. by damming and filling reservoirs with water) and levers for ensuring a larger energy consumption in periods of peak production (e.g. by producing more goods in a factory or by a smart heating of buildings upon demand) are two solutions. This leads to the so-called demand-response services, bringing new actors into the landscape, from electricity consumers (e.g. electric heating actors) to demand-response intermediates.
4. *Connectivity services*: The highly distributed nature of the smart grid calls for communication networks that connect energy generation, storage and consumption facilities. A highly reliable communication network with ubiquitous coverage is needed. On the other hand, smart metering is needed on the consumer's side in order to monitor the consumption and understand it (e.g. via big data analytics) and actuators are also needed for controlling the energy usage. Internet of Things (IoT) players thus become actors in the smart grid ecosystem.[2]

2.2 Examples of current positioning of MNOs in the smart grid ecosystem

Before going into details of the current and expected roles of MNOs in the smart grid ecosystem, we review some current relations in service provisioning between telecom operators and energy providers using examples from Europe and Africa.

In Europe, bundling strategies have emerged, for instance in Poland, where the telecommunications operator Orange is offering a national retail service on Energy: Orange Energia. Orange buys electricity on the wholesale market and then resells it in addition to its retail telecommunications services to different segments: residential customers, independent workers and SMEs (Small/Medium Enterprises). Another example is Pepephone, a Spanish MVNO (Mobile Virtual Network Operator, i.e. providing mobile communication services without operating the mobile network), which has launched an electricity supply business, Pepeenergy, exporting its low-cost model to the electricity distribution market.

From an African perspective, M-Kopa Solar (M for mobile, 'kopa' means to borrow in Swahili) is a company operating in Kenya, Tanzania and Uganda, connecting people to solar energy by making use of mobile technology. M-Kopa provides a kit for solar power generation that the client acquires after paying an upfront price and then further regular payments until the solar system is paid off. As such, M-Kopa has built a business based on solar energy targeting poor, off-grid households. What is of particular interest concerning this enterprise is that it combines technologies in the realms of cellular communications, mobile payments, financing and renewable solar power generation in a unique way to meet needs for electricity and beyond in the sub-Saharan Africa context, addressing low-budget clients. Most recently, Orange diversified into proposing electrification services in African countries where it operates, also targeting off-grid rural populations' access to solar energy by proposing individual solar panel kits. Following the launch of Orange Energie in the Democratic Republic of Congo in December 2017, and Mjiro (M for Mobile, jiro for 'light' in Malagasy) in Madagascar in February 2018, Orange announced in March 2018 the launch of this service in Burkina Faso, and further ahead in Senegal, Mali, Guinea and Ivory Coast (Orange, 2018).

Another important field where MNOs actively contribute to the smart grid evolution is the Internet of Things (IoT). For example, US-based Verizon Telecommunications Company added as per end 2016 a demand-response mechanism to its energy IoT cloud platform (Renaud, 2016).

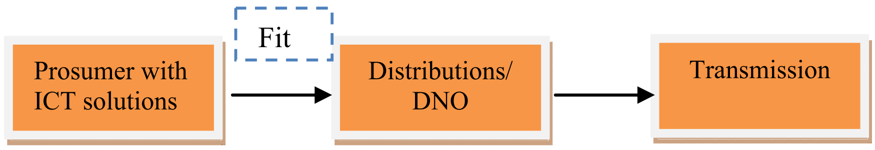
Although these examples clearly indicate that players from the telecommunications sector are starting to take their place in the different smart grid activities, there is a need for a clear vision on how the MNOs' assets position them in this promising business. In the subsequent sections we develop the smart grid ecosystem from an MNO perspective.

2.3 MNOs' role in smart grid-related activities

2.3.1 MNO as prosumer, VPP or small-scale storage facilitator

The term provider/consumer, or 'prosumers', can have many different meanings but, in a smart grid context, it is increasingly used to refer to electricity consumers who decide to install a small-scale energy generator on their premises, thereby becoming electricity producers providing for their own consumption needs. The current Feed-in Tariff (FIT), whereby prosumers get paid for each excess kilowatt hour that they produce and feed into the grid, reinforces the position of prosumers and encourages renewable energy investments by individuals and small companies. The position of prosumers is illustrated in Figure 2

Figure 2 Prosumers in the smart grid value chain in a FIT model. The arrows indicate electricity flow



However, the FIT model is changing in some countries, like the UK, leading to the emergence of Virtual Power Plants (VPPs) and to significant changes to the market, as shown in Figure 3.

An MNO can participate in distributed generation for itself and act as a prosumer. It may have renewable energy sources on its base station sites. An MNO can also play the role of VPP for itself and for other prosumers, based on its customer relationship (its large customer base) and its communication network.

We now place the MNO in this context. In fact, the MNO is present in three positions of the value chain in Figure 3. It acts as a prosumer as it consumes energy and may generate it; it also has a small-scale storage infrastructure due to its batteries in base stations, and it can play the role of VPP based on its customer relationship and its communication network. This is illustrated in Figure 4.

Figure 3 Prosumers in the smart grid value chain with intermediates

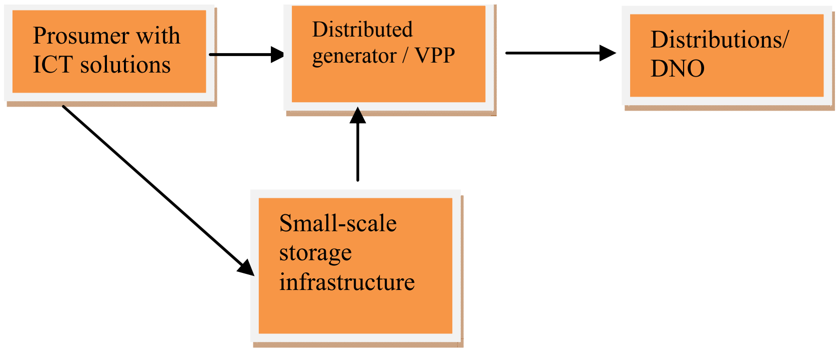
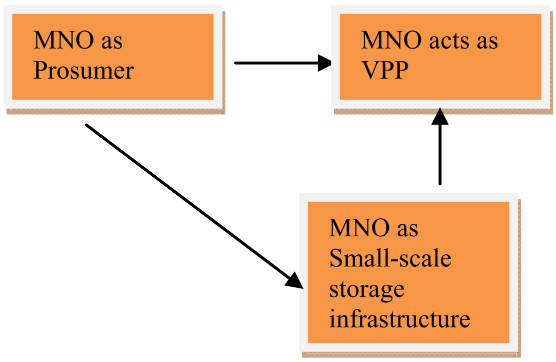


Figure 4 MNO as prosumer and VPP with storage facilities



2.3.2 MNO as demand-response aggregator

Demand-response refers to the modification in the user's electricity consumption in response to supply conditions (Geelen et al., 2013).

The Federal Energy Regulatory Commission defines demand response as 'Changes in electric usage by end-use customers from their normal consumption patterns in response to changes in the price of electricity over time, or to incentive payments designed to induce lower electricity use at times of high wholesale market prices or when system reliability is jeopardized.' (For more details see Balijepalli et al., 2011; Eid et al., 2016.)

With the variability and uncertainty of renewable energy sources, demand response will play a more important role and give much more flexibility for the grid.

A demand-response aggregator makes the link between distributors and consumers so that houses/electrical loads can be used as a grid-balancing mechanism; this can be done based on an external trigger (e.g. an electricity price).

Building upon historical and actualised knowledge of its clients, an MNO can, especially if active in the IoT and smart metering business, distinguish the clients who are likely to agree to lower their energy consumption, and propose to reward them for such an action on their part. Clients in this context can be industrial sites, but consideration should not be limited to them. Other energy consumption instances, such as local authorities, tenants of buildings, etc. that consume and eventually produce and store energy can be added to the list of potential partners for demand-response services. In the long run, residential clients connected to the grid can be included, provided their additional energy consumption is worth harnessing.

2.3.3 MNO as a connectivity provider and IoT player

As explained above, communication infrastructure is needed for operating the smart grid. 'Owning a private communications network, however, may not be an option for all TDSOs (Transmission and Distribution System Operators) for reasons of cost, lack of in-house network design and maintenance skills, or capacity to deploy applications expeditiously' (Deshpande et al., 2010). However, electric utilities are now offering a nearly universal service, especially in many geographies where no suitable communications networks currently exist or where the commercial (2G/3G/4G) communications network does not have the desired reliability. Utilities are also thus deploying dedicated telecommunication solutions based on RF Mesh or PLC (Power Line Communications). Their motivation is to take control by taking ownership. However, those technologies are often proprietary, which results in technical and vendors lock-in. 5G networks are expected to provide a standardised solution for a smart grid connectivity solution, characterised by a high reliability and a low latency (METIS, 2016).

Other challenges face MNOs as players in the IoT field. Indeed, 'on one side every object on the planet is getting a connection, which should open huge opportunities, but on the other side IoT connectivity cannot be expensive to guarantee a positive IoT business case' (5G PPP, 2015). This calls for a 5G network that is able to connect a huge number of devices at low cost and on the same physical network infrastructure as mobile broadband services [5G aims at offering all services on the same network and not on separate networks like LoRA (Long Range, a wireless data communication IoT technology)].

The third challenge in this context is related to generation and consumption forecasts that 'can help DSOs (distribution system operator) plan for possible imbalance situations in advance. This requires that the operator has detailed information about short and long-term generation and consumption profiles and expected consumer consumption during absence periods' (5G PPP, 2015). MNOs have a direct relationship with customers and have a large experience in big data analytics, allowing them to play a major role in this forecast activity in the long and short terms.

3 Business model for MNOs interacting with smart grids

Building on the ecosystem analysis of the previous section, we dedicate this section to the development of business models for an MNO that diversifies its service into smart energy. At a general level, a business model describes how a company conducts its activities. It represents the strategic positioning of the firm in a market (Yip, 2004) and defines how a firm creates and captures value for its stakeholders (Chesbrough, 2007; Casadesus-Masanell and Ricart, 2010). The business model spans firm and industry boundaries. It explains how a company's resources and competencies allow it to develop a value proposition for its various customers (B2B and B2C). There are close links between business model, value chain and value network.

There are several taxonomies of business models (Baden-Fuller and Morgan, 2010) based on various criteria. The components of the model reinforce each other. By definition, models (and business models) are simplifications of reality, and never entirely reflect the complexity of a dynamic economy (Daidj, 2015) but they are very useful in reaching a better understanding of key issues (value creation, revenue models). Among several representations of business models (Afuah and Tucci, 2000; Alt and Zimmermann, 2001; Zott et al., 2011), we have decided to follow the business canvas model developed by Osterwalder and Pigneur (2010) who have provided a methodology to analyse and explore business models by introducing the classification and studying equilibrium among the key elements (in total nine) that constitute them.

Analysis within the canvas identifies why the customers will decide to opt for the proposed service (value proposition), which are the customers and how to get to them (customer segments, channels to address the customers, as well as customer relationships), and finally the main operations to conduct in order to get into this new business (partnerships, activities and resources).

Based on analysis of previous developments, in this section we explore and propose three business model canvas variants for a mobile network operator (MNO) that may decide to get associated with the smart energy business.

3.1 MNO as demand-response aggregator

The first one places the MNO in the role of demand-response aggregator. According to Xerfi (2015), 'Value is no longer to be found in simply generating and supplying power and gas. Smart-grid customer-focussed solutions such as products and services for energy efficiency, digitalisation and connected homes offer considerable value potential (…) Opportunities are customer-centric, technology-driven and small-scale.'

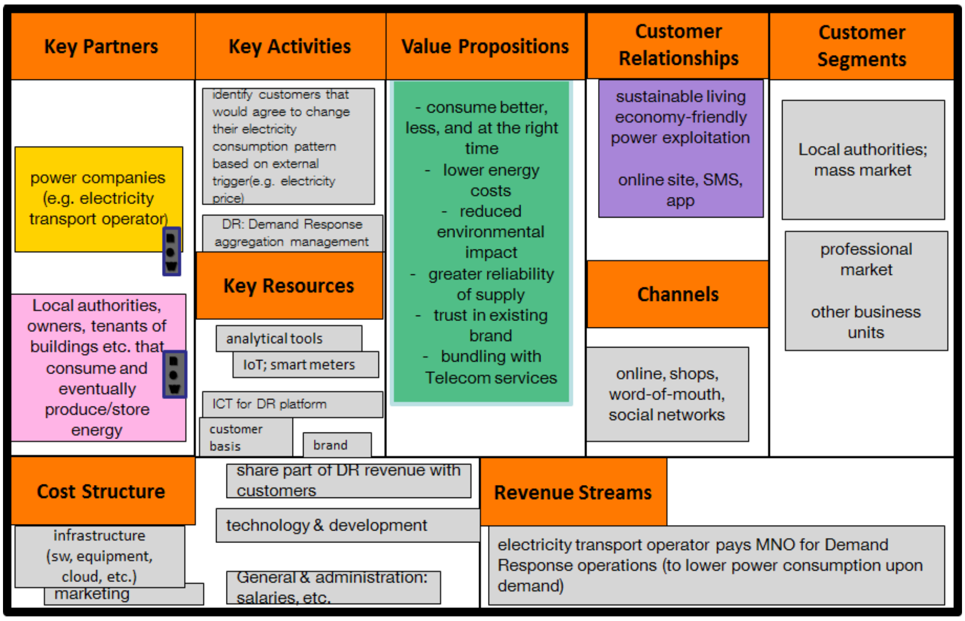
For an MNO deciding to get into the demand-response services, it could be interesting to exploit and enhance user profile knowledge in order to diversify its business and achieve greater reliability of supply.

With the previous in mind, the following business model canvas is proposed, placing the MNO in the demand-response aggregator role in Figure 5.

In this model, the MNO identifies and triggers clients who will agree to change and to lower their energy consumption at a certain time, based on a change in electricity price.

The value proposition, at the centre of the business model canvas, provides the reasons why customers will opt for the proposed service: in order to consume better, less and at the right time. Another reason could be for lower costs and reduced environmental impact, in exchange for a greater reliability of supply. This is particularly the case for an established MNO, because clients trust the existing brand and profit from bundling with Telecom services.

Figure 5 Business model canvas – MNO as demand-response aggregator



An MNO can, especially if active in the IoT and smart metering business, distinguish the clients who are likely to agree to lower their energy consumption and offer to reward them for such an action on their part. The MNO can accomplish that, building upon historical and actualised knowledge of its clients.

Clients in this context can be industrial sites/professional clients (B2B), as is up to now the case for demand-response initiatives, but these clients are by no means the only ones that can be considered. Other energy consumption instances, such as local authorities (Business to Government, B2G),tenants of buildings, etc., that consume and eventually produce and store energy can be added to the list of potential partners for demand-response services. In the long run, residential, mass market clients (B2C) connected to the grid can be included, provided their additional energy consumption is worth harnessing. Even though a fine-tuned value proposition should take into consideration specificities of these different particular clients, the initial value proposition that is suggested in the current business model canvas can hopefully accommodate each of the proposed client segments, as all of them are impacted by environmental challenges, sometimes linked to Social Responsibility Ethics objectives, in a cost constraint context.

In this scenario, the role and activities for the MNO are built around the need to identify and capture customers willing to abide by the rules and who agree to change their electricity consumption at specified times, based on an external trigger (typically electricity price).

A partner power company (most probably an electricity transport operator) would pay the MNO for demand-response operations in order to lower power consumption upon demand, as concerns revenue stream in the business model canvas. In the cost structure part, the MNO will have to share part of the demand-response revenue with the customers who accept the transaction.

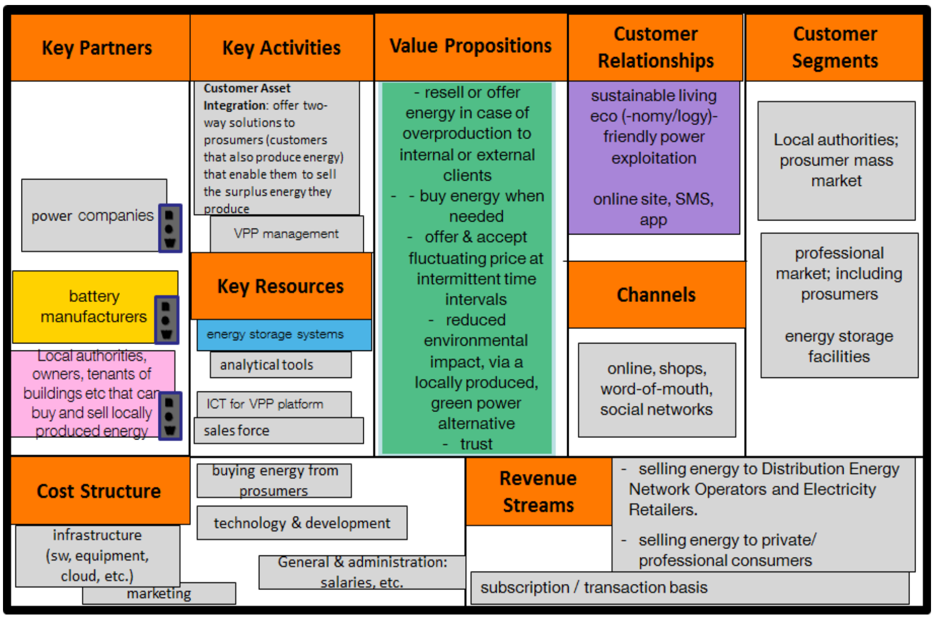
As concerns the key resources to put in place, we can differentiate between tangible and intangible resources. Tangible resources include IoT and smart metres installations, while intangible resources accommodate for the software platform for demand response, related analytical tools, the customer basis and the existing brand. The latter two intangible resources are shared with other services, while the software platform for demand response is specific to the proposed service.

3.2 MNO as VPP (Virtual Power Plant)

The second service further moves the MNO into a VPP role where, as explained in Section 2.2.2, the changing nature of distributed electricity generation allows an MNO to play the role of VPP for (electricity) prosumers, based on its customer relationship (its large customer base) and its communication network. A multi-sided platform can be put in place, to enable the association between those generating electricity to be sold and those wanting to buy electricity at a specific point in time. Both professional and individual clients can be involved in this case. Here, buying or selling energy may signify either that the MNO is indeed buying and selling energy to third parties, or that the MNO is a facilitator enabling these transactions via the proposed platform.

An MNO getting into the VPP aggregator role can also exploit and enhance user profile knowledge to diversify business, gain access to a greater reliability of supply, and also exploit a gap in practices between the wholesale (much cheaper) and residential (more expensive) market (fluctuation vs flat pricing). The related business model canvas placing an MNO in the role of a Virtual Power Plant is proposed in Figure 6.

Figure 6 Business model canvas – MNO as VPP (Virtual Power Plant) aggregator



This service builds on ongoing evolutions in generating and consuming electricity (Tantau and Staiger, 2018). As such, this service associates those who produce and want to sell surplus electricity with those who want to buy electricity at a certain point in time.

The operator buys energy from prosumers and generates revenue by selling energy to distribution Energy Network Operators and electricity retailers, or directly to energy consumers.

As concerns key resources, energy storage systems are a new, optional tangible resource to envisage, as compared to the previous service of the MNO as demand-response aggregator (while it becomes mandatory for the third service that will be elaborated further down).

Furthermore, new relationships with battery manufacturers as key partners have to be introduced.

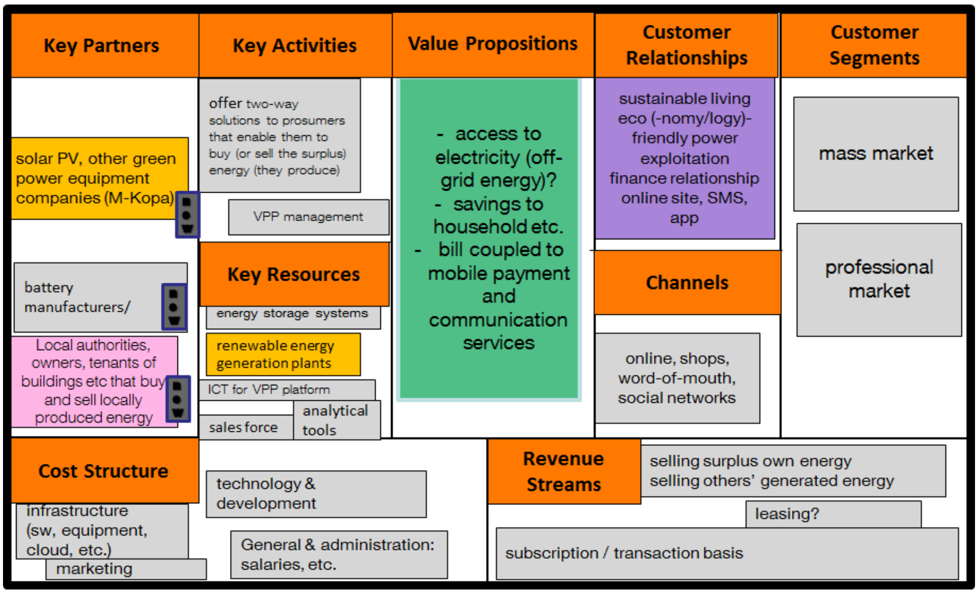
3.3 MNO as prosumer and VPP with storage facilities

In the event that the MNO decides to buy energy at preferential prices, it may need to exploit the existing and to-be-built energy storage system, so as to store energy bought at low prices and use it up or sell it when electricity prices are high. An MNO can use the battery infrastructure deployed at base stations, currently used for securing base station autonomous functioning in the event of grid failure. In the future, these base station batteries can contribute to storing and using (charging and discharging) electric power, as is the case for electric vehicle-to-grid and grid-to-vehicle services (Niesten and Alkemade, 2016). The decentralised nature of antenna locations is well in line with decentralised power generation coming from prosumer sources.

The third business model canvas assumes the MNO is itself a prosumer and thus is generating the necessary energy for powering the MNO equipment and facilities. In this latter situation, the MNO is in the position to sell own-generated renewable energy to energy distributors. Here the possibility to deploy renewable energy sources on the MNO radio sites is explored, coupled with energy storage capabilities in the mobile network. Currently renewable energy storage (such as battery technology) is 'the missing piece in renewable' (Xerfi, 2015), but research on battery storage is ongoing. Most recently, energy actors have made movements in this sense: EDF has forged a greater presence in wind and solar and related energy storage systems, Enel acquired in May 2017 a battery energy storage system (BESS) project in Newcastle, UK, Engie has invested in and partnered with innovative companies on energy storage and E.ON is focusing on energy storage via for example the launch of the SolarCloud and Google Sunroof (Xerfi, 2017). As of March 2017, E.ON announced it was building two batteries with a total storage volume of 20 MW in Texas, USA as part of its efforts to expand into the energy storage market in the US. At the same time, E.ON and Google launched the Sunroof platform in Germany, which can 'precisely' determine the potential solar capacity and cost benefits of each homeowner, leveraging Google Earth and Maps, 3D models, and machine learning (Xerfi, 2017).

For an MNO embracing this new role, the implications are to diversify into electricity production, distribution and retail, especially in locations where the grid is not present, reliable or cheap enough, and to address social and environmental challenges. Figure 7 provides the related business model canvas.

Figure 7 Business model canvas – MNO as prosumer and VPP with storage facilities



In addition to the previous service, that of a VPP aggregator, now the MNO is itself in the position of a prosumer and can generate the necessary energy for powering the MNO equipment and facilities. As such, the MNO is in the position to sell own-generated renewable energy to energy distributors.

Here the possibility of deploying renewable energy sources on the MNO radio sites is explored, coupled with energy storage capabilities in the mobile network.

This third service introduces new, tangible key resources: energy storage systems and energy generation systems. Respectively, new energy generating partners are needed among power equipment manufacturers.

The key idea in the proposed service is for the MNO to store energy purchased at low prices, and either use it up for its own needs (related to telco network operations) or sell it when electricity prices are high.

4 Application to various contexts

Business models presented previously could vary according to various regional and local contexts.

4.1 The case of European countries

As concerns the European power sector, over the past decade the landscape has been radically altered by liberalisation. There is a tendency towards more decentralised and geographically spread electricity generation. Political factors have equally spurred on renewables, which now account for over a third of Europe's power generation and whose share is set to grow (Xerfi, 2015). These factors require a change to the traditional energy business model, to which utilities must continue to adapt.

European electricity consumption has been dropping over the last five years and this trend is expected to continue in the mid-term. This is partly due to slow economic growth but also increased energy efficiency and a shift away from energy-intensive industry (Xerfi, 2015).

This falling demand is hampering utility companies' sales, but a surplus of energy due to large volumes of renewable production capacity as well as falling coal prices has led to a drop in electricity spot prices. Also, the expansion of renewable energy is putting pressure on conventional power station margins and utilisation, as renewables are not only subsidised but also often given priority on the grid. The political will to unbundle areas of the value chain have reduced synergies, and thus margins for utilities. Utilities are increasingly seeking cost reductions, greater efficiency and streamlined portfolios. In their hunt for margin growth, power and gas utilities are widening their range of products and services to tap into new trends such as smart grids, e-mobility (such as electric cars) and 'prosumer' needs.

In this context, the demand-response aggregator in the smart grid role or the VPP aggregator role, as presented in the previous sections, can be explored to extend the mobile operator role into that of an enabler, an aggregator in energy production and provisioning. Please note that demand response and VPP are distinct services that entail different activities to be put in place, as well as mobilising different resources.

Techno-economic studies investigating renewable energy generation for covering telco energy needs are not currently converging to the option of own-generated renewable energy, although this has to be continuously re-evaluated in the light of the continuous fall in the price of renewable generation installations, as observed in 2017 and 2018.[3] This is, however, not the case for the context of African-based operations, as shown in the following section.

4.2 The case of African countries

In most African countries, where the electric grid is neither ubiquitous nor reliable in time, mobile communications operators have invested in mostly renewable power equipment to generate the necessary energy for base station towers. People living in the vicinity of the tower installations became interested in getting access to electricity, both in order to charge their mobile phones and for their domestic use. Therefore, an ecosystem has been developed around mobile base station installations, where it is not only the mobile communications but essentially the access to electricity that matters.

In this context, electrification can become an asset that can eventually help the business grow. We propose to take inspiration from the Electric Vehicle (EV) aggregator model, as described in Niesten and Alkemade (2016), extending operations from the mobile provider only to that of a telecom operator that produces electricity for its own needs, then uses surplus production to offer electricity services to clients, and, at a latter point, buys electricity from client prosumers depending on predicted needs.

'The EV aggregator brings together supply and demand for electricity by offering V2G and G2V services to the actors, thereby creating and capturing value in two different ways. First, it creates and captures value by purchasing electricity on the electricity market at low prices to charge batteries of EV owners, EV fleets or battery switch stations, and it discharges batteries to sell electricity on the market at high prices.

Second, it creates and captures value by offering electricity and capacity in EV batteries to system operators in the form of ancillary services (e.g., regulation and reserve power)' (Niesten and Alkemade, 2016).

This model can be transposed to one where batteries for charging electric cars are replaced by batteries for charging mobile base stations. This requires a change of paradigm, where electricity production turns from necessity into a key resource.

In this manner, the lack of electric infrastructure is turned into an opportunity, under the assumption that potential flexibility of demand at customer level would be higher and, if harnessed, could be used for resolution of localised network constraints and for better management of power flows at grid operating level.

One has to bear in mind that, across Africa, the demand for electricity is projected to triple by 2030, offering huge potential for renewable energy sources. A World Bank report notes that[4] only 23 per cent of Kenyans, 10.8 per cent of Rwandans and 14.8 per cent of Tanzanians have access to an electricity supply. In Uganda, only 17 per cent have access to electricity, according to the Ministry for Energy and Mineral Development. Therefore, institutions producing solar power can sell redundant power during sunny days and buy electricity from the grid during rainy days. According to a recent source,[5] electricity demand for the sub-Saharan population is expected to increase by four per cent year on year, but the supply shortage already results in frequent blackouts. The same source states that 'if sub-Saharan Africa is to meet the UN Sustainable Development Goals, including goal 7 to ensure access to affordable, reliable and modern energy for all and goal 13 to combat climate change and its impact, electricity should not only be affordable and reliable, but also from clean energy sources.' Therefore getting affordable electricity to the sub-Saharan population is a multifaceted challenge, with economic and political difficulties, where nevertheless renewable solar energy projects appear promising. There solar power can be stored based on solar thermal technology (solar energy is turned into heat, stored in molten salts, used to generate steam and in turn this steam drives a turbine to generate electricity).

In this context, the third business model canvas, as presented in Section 3.1.3, where the MNO also acts as an enhanced VPP that commercialises its own-generated renewable energy, seems well suited to sub-Saharan African countries.

5 Conclusion

The classical electricity grid value chain is experiencing radical changes with the advent of smart grids. The emergence of new players is driven by the following four main activities of the smart grids: renewable energy generation, renewable energy storage, demand-response services and connectivity services.

Based on these main activities, we developed the smart grid ecosystem from an MNO perspective. We first identified examples that illustrate existing synergies between the telecom and energy provisioning worlds. Based on the general analysis of the activities in the smart grid and on these real-life examples, we developed the position of the MNO with regards to the four main activities. We found that the mobile network operator, besides its strong position in the connectivity and IoT domain, can play an important role in distributed energy generation and storage. Indeed, not only can the MNO act as prosumer of renewable energy, relying on its storage capabilities and the possibility of deploying renewable energy sources on its base station sites, but also it can act as a VPP (Virtual Power Plant), exploiting its customer database and communication infrastructure.

Going further in the analysis, we have developed the business model canvas for three retained cases of interest, namely MNO as demand-response aggregator, MNO as VPP, and MNO as prosumer and VPP with storage facilities, embracing commercialisation of own-generated renewable energy.

Upon offering demand-response services, an MNO can build on client knowledge, IoT and smart metering activities.

If further extending to the Virtual Power Plant Aggregator role, a multi-sided platform can be put in place, to enable the association between those generating electricity to be sold and those wanting to buy electricity at a specific point in time.

These two services, demand response and VPP Aggregator role, could well be mapped to the European context, where electricity retail prices are getting higher, consumption is dropping, there is a political will to unbundle areas of the value chain and where the notion of prosumer (electricity producer and consumer) is extending to both business and residential sectors.

Where the mobile operator invests in renewable energy generation, as is already the case in sub-Saharan Africa, it would be interesting for the MNO to investigate the business opportunity of an enhanced VPP aggregator, where it also assumes the commercialisation of its own-generated renewable energy, selling surplus production and buying electricity from clients depending on predicted needs.

In their social responsibility agenda, Mobile Network Operators have already undertaken a role in support of the energy challenge and are already active in increasing energy efficient networks and IT systems, promoting energy and environmental transition. MNOs are fixing targets to reduce their CO_2 emissions, to protect the natural environment and resources via the responsible usage of materials used in equipment (both network infrastructure and end-user devices) and recycling. Algorithms and network architecture are built with energy efficiency in mind. In addition, as actors in the digital world, operators are enabling solutions for smart cities, smart transport and smart metering, among others. In this article, we have explored yet another possible role for a telco operator: that of an actor in, and not just a consumer of, the smart energy grid.

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Notes

1 Accredited renewable energy power stations are entitled to create large-scale generation certificates based on the amount of eligible renewable electricity they produce above their baseline. As a guide, one large-scale generation certificate is equal to one megawatt hour of eligible renewable electricity.

2 In this paper, we use the term 'ecosystem' to mean a large network of various private and public companies operating in a given sector.

3 https://www.bloomberg.com/news/articles/2018-07-26/renewable-energy-giant-shifts-toward-grids-to-shore-up-returns

4 Spate of new investments in East Africa's solar energy. *Source:* Factiva / The East African – 26 October 2015.

5 How sub-Saharan Africa can harness its big electricity opportunities. *Source*: Factiva / AllAfrica – 8 June 2018.